Concepts and Trends in Particle Physics

(Proceedings of the XXV Int. Universitätswochen für Kernphysik, Schladming, Austria, February 19-27, 1986)

edited by H Latal and H Mitter

Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo, 1987
ix + 325 pages, 48 figures ; price : DM 87 (Hard cover) ; ISBN 3-540-17372-2

This volume consists of an impressive variety of topics in modern theoretical particle physics incorporated in a rather compact size. The main focus is on those aspects of elementary particle theory that are currently in vogue, namely Kaluza-Klein Theories, Supersymmetry (including supergravity). Superstring Theories, and the Fermion Mass Hierarchy in the Standard Model. Also included are two articles on numerical simulations in Yang Mills gauge theories—a subject that continues to be at the forefront of research in strong interaction dynamics. Finally, as if to remind the reader that physics is ultimately an experimental science, an article on forthcoming experiments that probe physics beyond the realm of the standard model is included. All the articles are essentially written versions of lectures delivered at the Scladming Winter School, and are therefore pedagogical in nature, while being current and up-to-date. As most (if not all) of the lecturers are stalwarts in their respective areas, the book is very lucid throughout, and should be very useful to students intending to acquire a familiarity with what might perhaps be the forefront of research in modern particle physics.

The first article, by Blau *et al*, on Kaluza-Klein Theories, provides an extremely pedagogical introduction to the rudiments of the field, initiated more than half a century ago, and largely ignored till the end of the last decade. Included is a compact self-contained introduction to the theory of differential forms which should be useful even to readers not intending to pursue the rest of the article. Perhaps the only obvious flaw is the restriction of most of the discussion to five dimensional gravity, given that with the resurgence of string theory, it is ten dimensional spacetime which has become more important.

The article on supersymmetry and supergravity by Wess (one of the pioneers of the subject) is a condensed version of the well-known text book by him and Bagger, and displays the same mastery over the subject, although perhaps lacking in all the elegant details. As a rapid refresher course in the field, it is of no small value.

The introduction to superstrings is given by no less a person than G Veneziano, the man who started it all more than a decade ago. The remarkable insights of a

veteran practitioner make this article probably the most interesting of the whole collection. Also included is a succinct discussion of the topic of superstring propagation in background fields, a subject in which the author himself has made important contributions recently.

The next article is on the possible phenomenological ramifications of superstring theory, by G Segre. It comprises a detailed discussion of the seminal paper by Candelas, Horowitz, Strominger and Witten, replete with sufficient mathematical details, so as to make the complicated machinery of algebraic geometry accessible to the non-expert. Calabi-Yau compactification is discussed in detail from a phenomenological perspective, as is the question of gauge symmetry breaking. Although the state of the art in this area is not conclusive yet, this is a good survey of what the triumphs and pitfalls might be.

Peccei's paper on the issue of (fermion) masses is an elegant discourse on what appears to be the most difficult strumbling block of the standard model— the issue of the hierarchy of quark and lepton masses seen in nature. Related issues of CP violation, the strong CP problem, the Peccei-Quinn symmetry leading to the elusive axion proposed by Weinberg and Wilczek are discussed with a great deal of clarity.

The pair of articles by Satz, one of which is only given as an abstract, summarize current research in the area of numerical simulation of gauge theories. With the as yet uncertain links of superstrings to low energy physics, this area (especially on random lattices) is likely to become increasingly popular over the next few years.

For specialists in supersymmetric Yang Mills theories, included is an article on the application of non-covariant gauges in supergraph calculation. Although the subject is slightly outdated, the results presented here are no less interesting, and may have important consequences for superstrings.

Finally, the Nobel laureate L Lederman gives an interesting survey of experiments in progress, those which are scheduled to start shortly, and particle accelerators of the near future. The emphasis, understandably but unfortunately is on the hardware rather than the physics aspects, and may not be of much use to most of the users of this volume.

Despite the high cost of books published by Springer, I would recommend that any library that can boast of users who are particle theorists by profession, should attempt to procure this book.

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Electronic Band Structure and its Applications (Lecture Notes in Physics, Vol 283)

(Proceedings of the International School on Electronic Band Structure and its Applications held at the Indian Institute of Technology, Kanpur, India, October 20-November 8, 1986)

edited by M Yussouff

Springer-Verlag : Berlin-Heidelberg-New York-Tokyo, 1986
viii + 441 pages, price : DM 73 (Hard cover) ; ISBN 3-540-18098-2

The book under review is a proceedings of the international School of Electronic Band Structure and its applications, held at IIT, Kanpur from October 20 to November 8, 1986. The subject of band theory is very sophisticated and highly specialized and hence is only pursued by a small band of people throughout the world. Therefore holding an international Seminar on such a subject is a very commendable task. The organisers could also bring a no. of highly reputed scientists of international standing. The deliberations of these people will, therefore, be also of very high standard. This is, therefore, only be suited for those people who are either working in the subject or are intending to start research in this subject.

The first article in this book is on the "Linearized Band Structure Methods" by O K Anderson and his groups. Prof Anderson single handedly developed these linearized methods and hence, his exposition in this article adds a new flavour to this book. Although a separate book exists on these linearized methods by H L Skriver where computer programmes and other details are given, this article gives a very compact idea which is very helpful for a person who wants to start calculating band structure by these linearized methods.

In any band structure calculations one of the most important things is to find a reasonably good exchange potential without which the results of the band structure calculation will not be satisfactory. The article on 'Density-Functional formalism' by Gunnarsson *et al* describes a way to find the exchange potential in local density approximation. The article by W E Picket deals with the relationship of band theory to heavy fermion behaviour. All known heavy fermion systems are compounds which contain one atom type with a partially filled *f*-shell (such as Ce, Yb, U, Np or Pu) and at least one atom type with no partially filled *f*-shell. This observation and the known narrow band character of *f*-electrons suggests that the enhanced effective mass of heavy fermion systems arises from highly correlated *f*-electrons which are hybridized with the conduction electrons. These unusual properties of heavy fermions have been discussed in this article. Another article by A Bansil deal with disordered solids. He has developed in this article the average t-matrix approximation and the coherent potential approximation. Since both these approxi-

mation assume an effective medium the potential becomes complex as a result of which the bands becomes complex. He has beautifully described this aspects for disordered alloys.

The book contains a numbers of other articles which although directly does not fall under the title of the book but are very much related to the title. One or two articles on the prelimenaries of band theory would have been much more desirable.

However, on the whole the book is quite informative and covers a large area of the subject.

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Electronic Structure and Optical Properties of Semiconductors (Springer Series in Solid State Sciences, Vol 75)

by M L Cohen and J R Chelikowsky

Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo-Hong-Kong, 1988
xii + 264 pages, 161 figures ; price : DM 98 (Hard cover) ; ISBN 3-540-18818-5

It is a better understanding of the properties of semiconductors that led to the enormous advancement in electronics and computer science and resulted in to-day's high technology. The volume under review is an excellent treatment of both theoretical and experimental aspects of electronic structure of semiconductors. The authors intended to make a compromise between an instructional material and a research text book and surely succeeded in making a good balance between the two. For the students some basic ideas about electronic structure and semiconductor physics with applications have been covered. Tables and references will be useful to the researchers.

The book comprises twelve chapters. After intoducing the subject and discussing the scope of the book in the first chapter, the authors made a pleasant review of some general aspects of electronic structure calculation in the next three chapters. The one-electron model and band structure of solids have been presented in chapter 2. In chapter 3, pseudopotential method of calculation of disperson and other properties of semiconductors has been discussed. Importance of the empirical pseudopotential method for studying the optical properties of solids and the self consistent and *ab initio* pseudopotential methods for determining the electronic structure has been emphasized. Theoretical calculation of the response time which

provide accurate energy eigen values and wavefunctions has been presented in chapter 4.

Experimental methodology and the obserables have been dealt with in the following three chapters. In chapter 5, low energy probes such as radio to infrared frequency radiation and cyclotron resonance have been described. How the low frequency radiation effectively probe the states near the conduction and valency bands and how the dynamical masses associated with the bands are estimated by cyclotron resonance have been explained lucidly. In chapter 6, various modulation spectroscopic techniques and their advantages and disadvantages have been explained. Usefulness of synchroton radiation to study transitions from core states to the conduction band states, electron energy loss spectroscopy to measure the imaginary part of the dielectric function and photoelectron spectroscopy to probe electronic states of semiconductors has been described in this chapter. In chapter 7, the use of computer automated X-ray devices to obtain accurate crystal structure information and to measure Debye-Waller factor have been elaborated.

In the last five chapters, the structure of different classes of semiconductors and their energy band structure are discussed. While in chapter 8, technologically important diamond and zincblende type semiconductors, which comprise III-V and II-VI groups, are dealt with, in chapter 9 semiconductors of wurtzite structure with two interpenetrating lattices (ZnS/CdS etc.) are described. Chalcopyrite structure of ternary II, IV and V compounds which show interesting linear and nonlinear optical properties, is the topic of chapter 10. Semiconductor PbTe, PbSe etc. are low band gap ($\simeq 0.5$ eV) materials and are used in infrared lasers and detectors. Band structure of these materials has been discussed in chapter 11. In the final chapter structure of triatomic, layer, chain and amorphous semiconductors are treated.

Extensive bibliography on various properties of semiconductors and their energy band structures in an added attraction of the book.

The authors have worked diligently to collect large amount of information scattered in literature and to present it in a comprehensive fashion in a book of this moderate volume without loosing lucidity. This is a commendable achievement. It cannot be denied that "the book will serve as an excellent introductory text to newcomers to the field as well as an indispensible reference volume for research workers".

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Zero Phonon Lines and Spectral Hole Burning in Spectroscopy Photochemistry

edited by O Sild and K Haller

Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo-Hong Kong, 1988
ix+183 pages, 64 figures ; price : DM 72 (Hard cover) ; ISBN 3-540-19214-X

The book contains 183 pages with a foreword by Dr D Haarer of Bayreuth.

Studies of Zero Phonon Lines and of Spectral Hole Burning are facinating topics in condensed Matter Spectroscopy. It started in the early 1950's and preceded the Discovery of Mossbauer effect and is considered the Optical Analogue of Mossbauer Spectroscopy. Different aspects and applications of the interesting phenomenon have been discussed in this book by thirteen authors in eleven articles. Barring Krivoglaz of the Institute of Metal Physics, Ukranian S S R Academy of Science, the rest of the authors belong to the Institute of Physics, Tartu of Estonia.

The origin of the work lies in the pioneering research by E Shpol'skii who invented the method of producing quasiline Spectra of large molecules in solid matrices like perylene molecules in *n*-hexane. The Shpol'skii effect is a considerable narrowing of the inhomogeneous broadening of spectral bands by means of crystal chemistry– by choosing for certain impurity molecules appropriate solvents to act as solid matrices. The observed narrowing is however, several orders higher than that predicted theoretically. The Line width can be brought down to nearly the theoretical value by using Laser Beam and bringing the temperature down to absolute zero. One important observation is that of side bands which are caused by interaction with Phonons. This interaction does not cause any broadening of the Zero Phonon Lines but creates the side bands.

Dr M A Krivoglaz has contributed an important paper on homogeneous broadening of Zero Phonon Lines in the impurity Spectra of Crystals and glasses. This is followed by a scintillating article on the theory of Stationery and time-dependent Zero Phonon Line by Dr V V Hizhnyakov who discusses absorption and luminescence spectra of impurity centres with quadratic Vibronic Coupling and the compensation effect on the time-dependant ZPL Spectra. Electronic transitions are largely affected by impurity contents in the matrix. For ZPL Spectra effects of Small impurity molecules has been surveyed by Dr Freiberg and L A Rebana while those of Polyatomic including biogenic molecules have been discussed by Dr R Avarman.

In a very interesting paper Dr. J Kikas has discussed the scientific and practical application of ZPL Spectra. From the scientific standpoint the resolution of solid state Spectroscopy has increased enormously making it possible to study the effect

of Thermo-electric and Magnetic fields as well as mechanical stress, hydrostatic pressure etc. with ultra-high precision. As far as application standpoint is concerned, ZPL spectra has enriched the fields of optical information storage and transformation of optimal signals. New functional possibilities are revealed by time-and-space-domain holography.

There are several more papers elaboratingthese aspects of ZPL Spectoscopy. They are competently written and present a plethora of interesting information. The book is enjoyable studying. This is recommended for every student of condensed state matter science and technology.

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Core-Level Spectroscopy in Condensed Systems (Springer Series in Solid State Sciences, Vol 81)

(Proceedings of the Tenth Taniguchi International Symposium, Kashikojima, Japan, October 19-23, 1987)

edited by J Kanamori and A Kotani

Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo-Hong Kong, 1988
xi+303 pages, 157 figures ; price : DM 98 (Hard cover) ; ISBN 3-540-19112-7

Core-level spectroscopy has emerged in recent years as a major probe for elucidating electronic structure of molecules and solids. In the core-level spectroscopy, a core-electron is excited by either a photon or an electron and the various spectra associated with the excitation (photoemission, photoabsorption, fluorescence, Auger process and the likes) generate a wealth of information on the properties of valence electrons via the subtle interaction of the valence electrons with the core-hole. There are both single particle effects mediated by the core-hole (orbital relaxation) and many-body effects brought in by the changes in correlation accompanying the creation of the core-hole, and the simultaneous interplay of these two features produces spectral patterns that are not only very rich (with lots of satellites), but also symptomatic of the charge distribution and the spin properties of the system. The present volume collects articles which deal exclusively with the various aspects of the core-level spectroscopy of solids—notably in *f* and *d* electron metal alloys and compounds (oxides, halides etc.). Part I contains two brief but well-covered surveys on the many-body effects in core-level spectroscopy (A Kotani) and the

one-electron transitions in the XANES (A Bianconi) of solids. There is a nice discussion of the origin of the many-body effects in the article by Kotani, who also delineates the nature of power spectrum of the photoelectron. The multiplet splitting associated with the core-hole is succinctly described which serves as a good introduction to more specialized chapters to follow. Bianconi gives a very lucid pedagogical description of the band-structure approach to the computation of absorption coefficient in XANES of solid sciting typical examples. Parts II and III describe the many-body effects in *f* and *d* electron systems. Kotani *et al* discuss core-spectra of systems like CeO_2 and also theories of resonant photoemission spectra and X-ray radiation following core excitation in several papers. The underlying many-body hamiltonion is that of the celebrated Anderson impurity model. A complementary approach using propagator techniques is discussed by Sakai *et al*. Soda *et al* discuss the photoemission spectra of $CeCu_2Si_2$ and $CeInCu_2$. Of singular interest is the article by Gunnarsson *et al* on ab-initio calculation of the parameters in the Anderson model which should serve as a succinct "how-to-do" reference material for the experimentalists. Interesting off-beat papers are the ones by Igarshi on many-body effects on photo and inverse-photo emission and on trion formation in resonant photoemission in insulators. In view of the paramount importance of the role of inverse photo-emission techniques in mapping the virtual energy levels, the articles are of real topical interest. Part IV describes XANES, XAFES and related topics. Multichannel Scattering Theory is discussed with great clarity by Natoli and Benfatto which may serve as a standard review of the theoretical tools. I liked the articles on XANES of 3*d*-transition metals is discussed by Kasugi and patterns showing Plasmon-loss structures in the core-XPS by Fujikawa. Part V discusses surface effects. Fadley gives a very readable account of the recent developments in photoelectron diffraction which describes in a simple language the various techniques, covering the scanned-angle diffractions. Various systems are discussed—amply illustrating the method of analysis. Almbladh describes the theory of band—like Auger spectrum in SP-bonded materials, including the dynamic core-hole effects on the main band. Very instructive is the paper by Treglia *et al* on surface induced changes in the shape/intensity of the core-level spectra of transition metals. The theoretical formulation of the lineshape function is very useful, which is utilized in the elucidations of typical examples.

All the articles are of very high quality and reflect the then state of the art (1987) of the subject. In view of the recent enhanced activity, particularly induced by the recent works by Kotani, Almbladh and Kanamori, this book will be a good guide for the researchers in the field to venture deeply into the expanding frontier of this fascinating field where experimentalists and theoreticians have to go hand in

hand for understanding the structure and dynamics of the interacting core-valence systems characterizing a solid.

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